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VARIATIONS IN SOMATIC CHROMOSOMES.

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INTRODUCTION.

The chromosomes of the germ cells have received considerably more attention than have their descendants in the body and our knowledge of the behavior of these chromosomes is based on comparatively few studies of somatic cytology. During the process of karyokinesis in the body tissues the chromosomes may be studied, thus affording a basis for a comparison of their general characteristics and behavior with those of their ancestors or predecessors in the reproductive glands. Such investigations may eventually give an insight to some of the problems of development, including the function or activities of the chromosomes, and may also aid in strengthening the position taken in regard to these bodies by students of gametogenesis.

Cytologists have demonstrated that in any given species the chromosome number is constant and that in the diploid complexes of the germ and body cells the chromosomes exist in pairs. For a given species the chromosomes are frequently readily recognizable by characteristic structure and behavior. This numerical and morphological constancy has led to the theory of the individuality of chromosomes and is now so well supported by many observations that it may be said to be a part of the creed of modern biology. Indeed our knowledge has reached the point where numerical variations are not considered as *prima facie* evidence against the theory, but as another manifestation of an imperfectly understood organization.

The following report deals with the chromosomes in the so-

matic cells of the evening primrose, *Oenothera scintillans*, de Vries, and of the pig, *Sus scrofa*, in which the diploid chromosome number of the soma was found to be variable. The bearing of these facts upon the individuality theory is indicated.

THE CYTOLOGICAL CONDITIONS IN *Oenothera scintillans*.

The somatic, or diploid, number of chromosomes in *Oenothera scintillans* is fifteen. In material collected from three generations of these plants variations of this number have been found to range from fifteen to twenty-one. This diversity in number is not due to additions to the chromosome complex but to the fragmentation of certain individuals. From a preliminary study of the root tips of a fourth generation of *O. scintillans* I am inclined to believe that here the increase in chromosome number is not as great as just indicated. Breaks or clear areas occur in certain chromosomes which make what may be a single chromosome, appear as two. In my earlier material the possible relationship of chromosome portions on either side of the clear space was not so obvious as in the latest specimens. The last root tips collected present these portions in such perfect alignment as to suggest that they are a part of a common body. The clear areas are variable in extent and in certain cases one portion of the chromosome may be turned at right angles to the other. In a few instances the separation seems to be complete. The blank spaces in these "hyphenated" chromosomes may well be weak spots where under certain conditions breaks occur. As I have not yet determined the nature of these clear intervals in the chromosomes, for the sake of analysis, in this paper, all the separate chromatic bodies are considered as individual chromosomes.

Since the chromosomes are small and have no marked characteristics by which they may be recognized, measurements have to be resorted to. Some interesting results have been the outcome.

1. The total of the chromosome lengths of any complex whether it has the normal or higher number of chromosomes is the same. This indicated that no chromosomes have been added.

2. When the fifteen chromosomes of the normal complex are arranged according to decreasing length it is found that they

exist in a series of seven pairs plus one unpaired chromosome. Each pair differs from the pairs longer and the next shorter pair by almost precisely the same amount—nine per cent.

3. Since such exact relations exist between the normal pairs alteration in any of the chromosomes would destroy these conditions. This was found to be true in cells possessing more than fifteen chromosomes. Comparison with the standard lengths and relationships determined for the chromosomes of the normal complexes made it possible to reunite, with fair accuracy, the fragments to the chromosomes from which they had broken. This reunion has shown that it was chiefly the longer chromosomes that were concerned in fragmentation.

4. In the germ cells, the telophase chromosomes of the first maturation division are favorable for study. Two classes of cells are produced by this division, one of which has seven and the other eight chromosomes. This is due to the fact that the unpaired, and smallest, chromosome passes to one pole undivided. When the two complexes are measured it is found that total length of their chromosomes differ exactly by the length of the eighth chromosome, or the unpaired element. The same percentage of length difference exists between the individual gametic chromosomes as between the somatic pairs showing the two sets to be entirely comparable.

THE CYTOLOGICAL CONDITIONS IN THE PIG, *Sus scrofa*.

The work on the cytology of this mammal was made possible through an improvement in the preservation of the chromosomes which gave, I believe, the first true picture of the conditions in the cells of this group. Exception possibly should be made to the material used by Winiwarter in his studies, although it seems that the clear complexes were not as numerous as the other kind, whereas in the present specimens good mitotic figures were exceedingly abundant.

In the pig, I have found essentially the same cytological phenomena as in *Oenothera scintillans*. The spermatogonial chromosome number is forty and this appears to be constant. In the somatic cells the number ranges from forty to fifty-eight. As in the plant the extra number is caused by fragmentation and not

by additions, as the total length of the chromosomes of all complexes, regardless of the number of elements involved, falls within the total length limits established for the spermatogonial chromosomes. Furthermore, it appears to be the chromosomes of the long end of the series that are breaking up. In the normal complexes the chromosomes exist in pairs (not obvious until arranged according to length) and there is a relatively constant length difference between pairs. The normal complexes of the soma and of the spermatogonia agree in all particulars.

The fragments are not lost but continue as a part of the complex. They are never aligned with other chromosomes, as in *Oenothera scintillans*, in such a way as to suggest that they may be a part of those chromosomes separated from them by a clear space. The fact that in complexes made up of more than forty chromosomes fewer V-shaped elements are found led to a tentative suggestion in a recent paper (Hance, '17) that breaks occurred at the point of fibre attachment, *i. e.*, at the apex of the V. This gains some confirmation from the fact that the fragments (those chromosomes lying below chromosome 40 in the length series) are approximately the length of the short arm of the V.

GENERAL CONSIDERATIONS.

It is not possible, at present at least, to state the cause of fragmentation. Since the condition was found in a plant known to be unstable and in the pig which may very likely be genetically impure led to the suggestion (Hance, '17) that the phenomena might be in some way associated with hybridity. Such close breeding forms as the grasshoppers and the mosquitos are known to have a constant number of chromosomes in their body cells. There seems to be other evidence sufficiently strong and convincing on the other side to make the above idea a doubtful possibility rather than a reality. The chromosomes which break up may be multiples such as McClung and others have described but I think that there is considerable evidence against this. There is not enough known of somatic cytology, at present, to permit any sweeping generalizations.

Certain facts of chromosome behavior which are of general interest were disclosed through the employment of metrical

methods of analysis. The total of the chromosome lengths of any two complexes in any one form may be quite different and yet precisely the same relationship between pairs is maintained. If the total lengths of the chromosomes of certain cells differ, for example, by ten per cent. then the reduction of each chromosome of the "longer" cell by this amount will faithfully reproduce the length conditions in the shorter complex. In other words, anything influencing the length of the chromosomes in a cell will affect all proportionally. Consequently it can be readily understood that though the total lengths may vary considerably the interpair relationship remains constant. Data in support of these statements has been recently published (Hance,'17).

Since only the organization of certain chromosomes, and not the amount of chromatin, is disturbed by fragmentation it does not seem to me that the individuality is lost. It is true that certain chromosomes no longer exist as they were but since all the parts are retained intact in the complex the individuality hypothesis, as understood today, would seem sufficiently broad to admit these cases.

The discovery of the relationships of the chromosomes during the analysis of the unusual conditions just reported, is, I think, of considerably greater importance than the conditions themselves. Chromosome pairs exist in the soma and in the germ cells which are entirely comparable. When arranged according to length these pairs form a graded series. Between each pair there is a constant difference in length. These relationships exist in several other forms I have studied and appear to be fundamental. Besides presenting several new problems of chromosome behavior and organization, the constancy of these interpair relationships affords a check on the accuracy of cytological work and a basis for comparison with the work of others.

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Other papers of importance upon this subject are listed in the bibliographies of these two publications.